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Hybrid Systems Development by The Siemens Westinghouse Power Corporation

Presented to:

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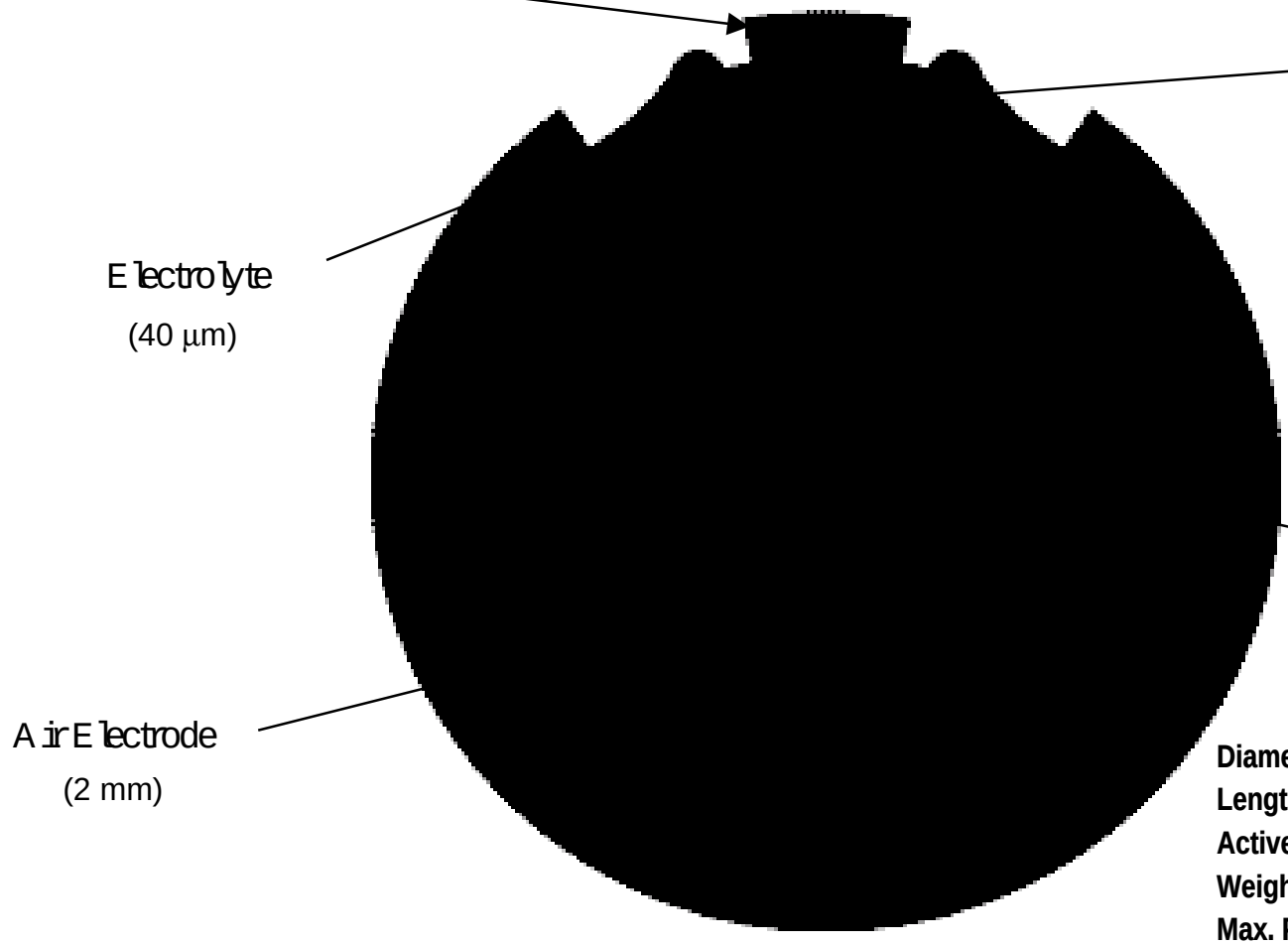
SOFC Technology Development Status

Air Electrode Supported Tubular Cell



Diameter:	**22 mm**
Length:	**1500 mm**
Active Area:	**834 cmsq**
Weight:	**1 kg**
Max. Power (T = 1000, atm):	**210 watts**
In-Stack Nominal Power (atm):	**110 watts**

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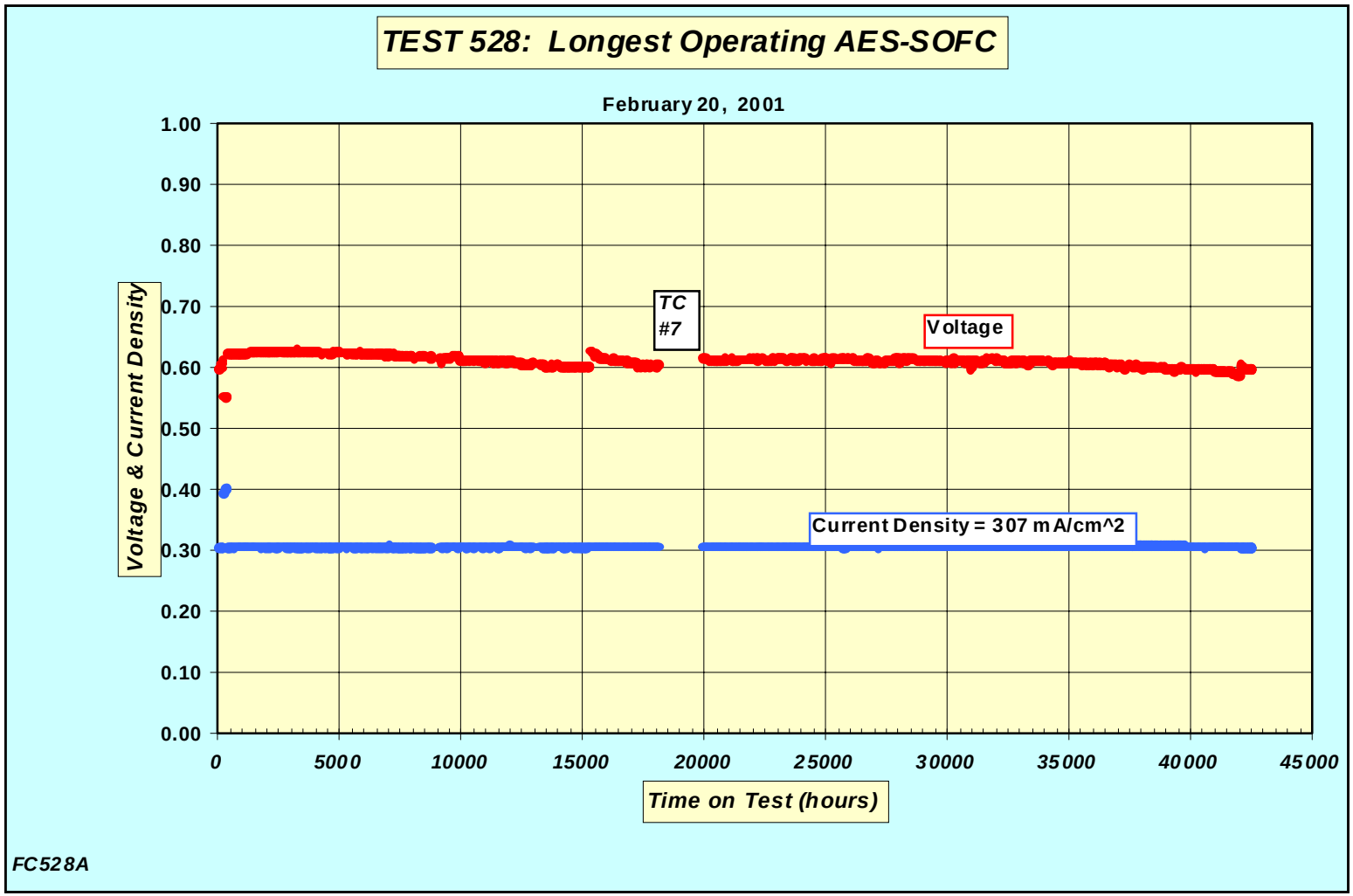
SOFC Technology Development Status

AES-SOFC Performance [T = 1000°C, FU = 0.85]



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SOFC Status

24 Cell Bundle

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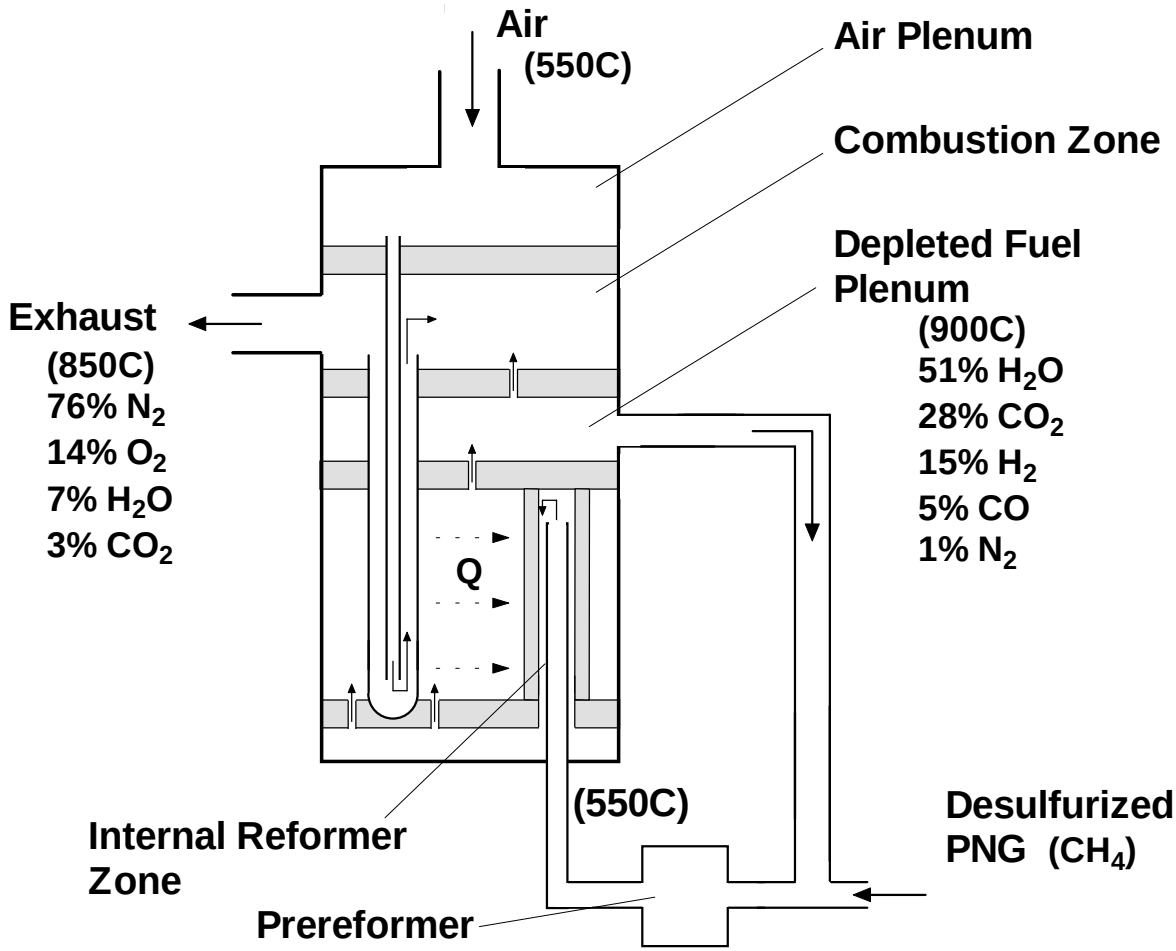
SOFC Demonstration Status

Stack Hydraulics



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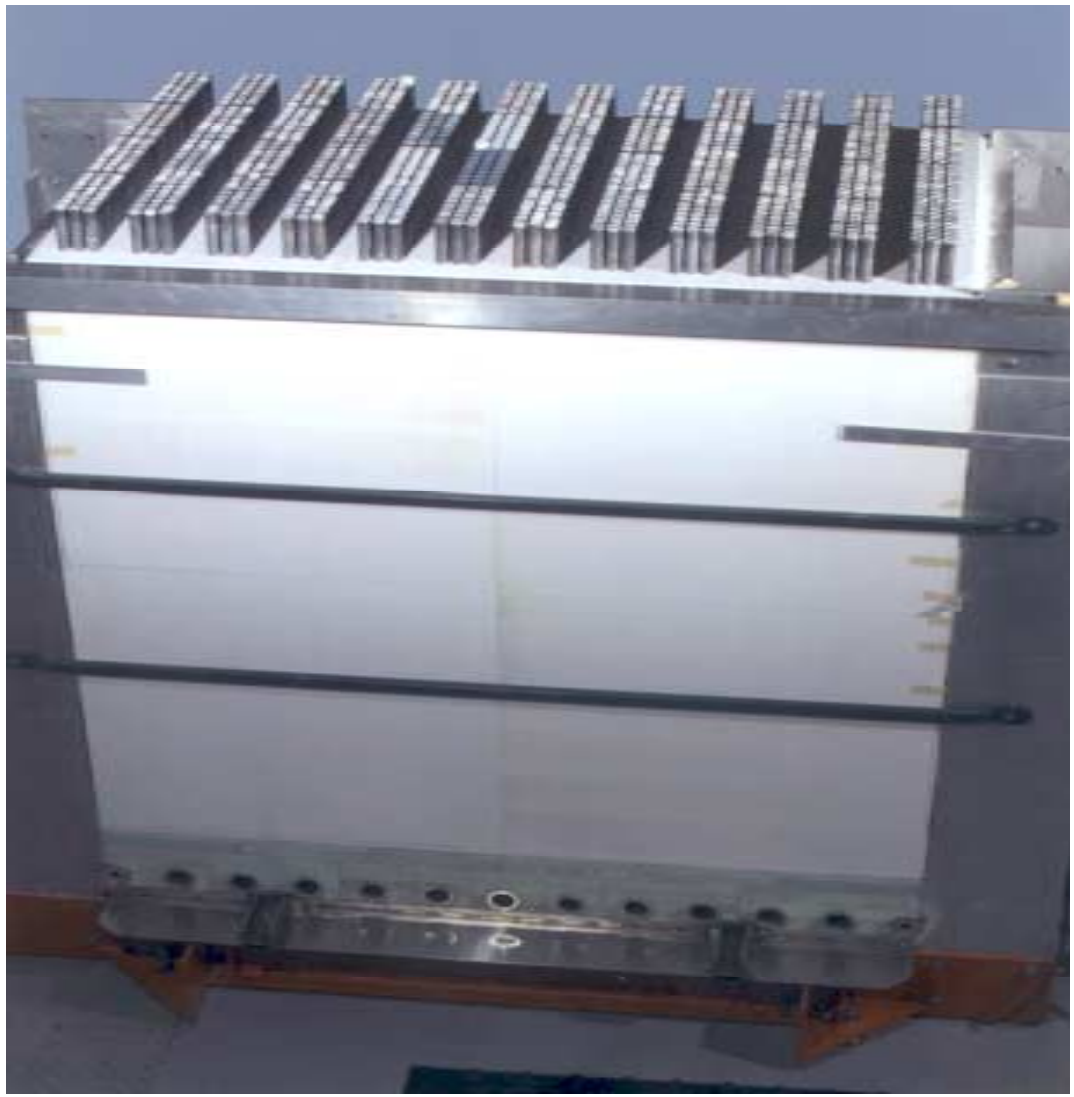
SOFC Demonstration Status

EDB-ELSAM 100 kWe Stack (48 bundles, 1152 cells)



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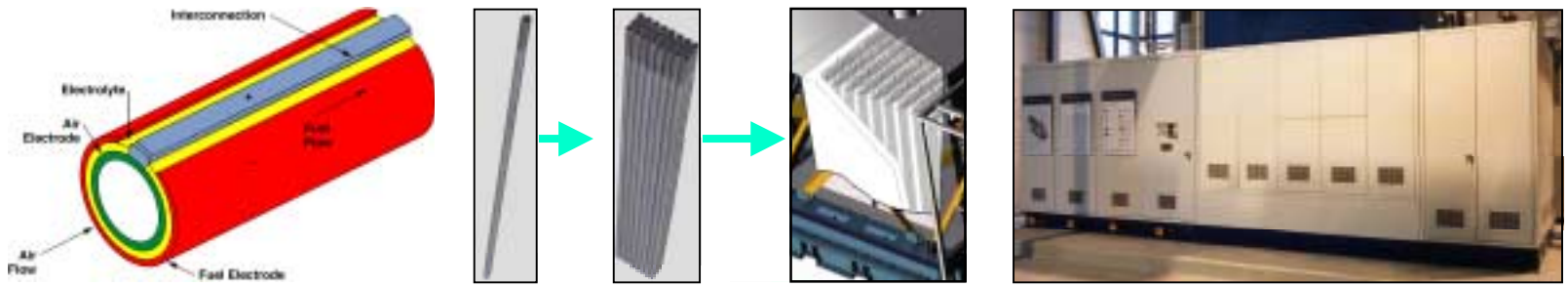
SOFC Generators
Cells to Systems

System **Cell + Bundles = Generator + BOP**



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SOFC Near Term Products

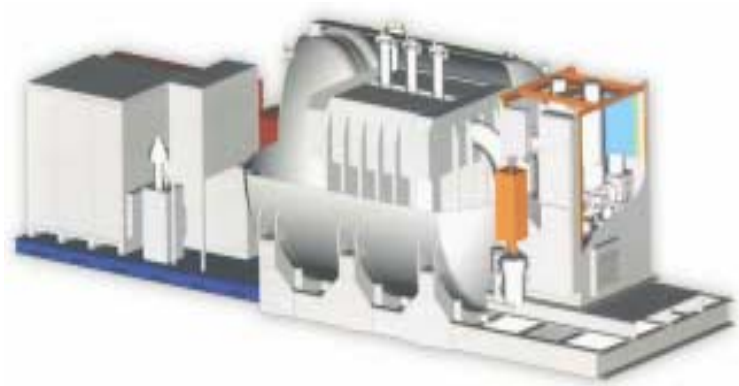
Two Commercial Product Classes

Atmospheric System:
250 CHP class

CHP: Combined Heat and Power;
250 kW e

Pressurized Hybrid
PH - System:

300 - 1000 kWe class



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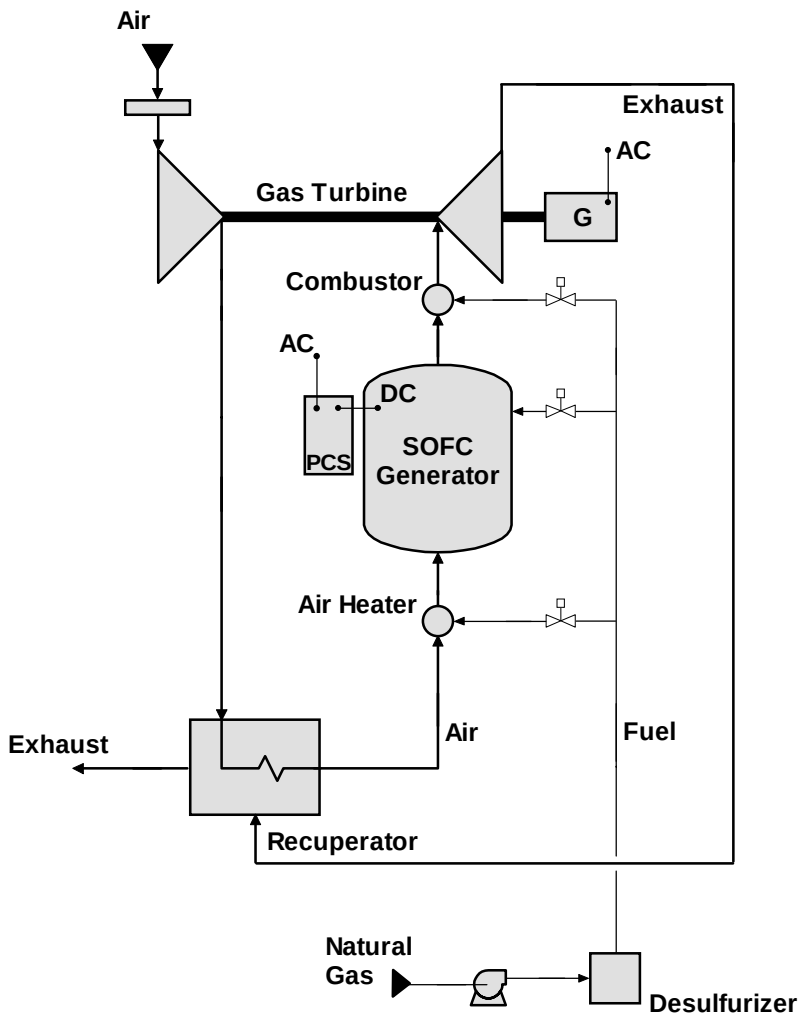
SOFC Demonstration Status

Basic PSOFC/GT Cycle



- Peak Cycle Temperature 870C
- Optimum Pressure Ratio ~ 3:1

System Efficiency Horizon ~60% (NetAC/LHV)

Why High Efficiency Is Achieved

- All Fuel is Reacted by the SOFC
- SOFC Exhaust Heat is Converted to Additional Power by the Gas Turbine Cycle.
- The SOFC Generator is Pressurized ⇒ Improved SOFC Performance.

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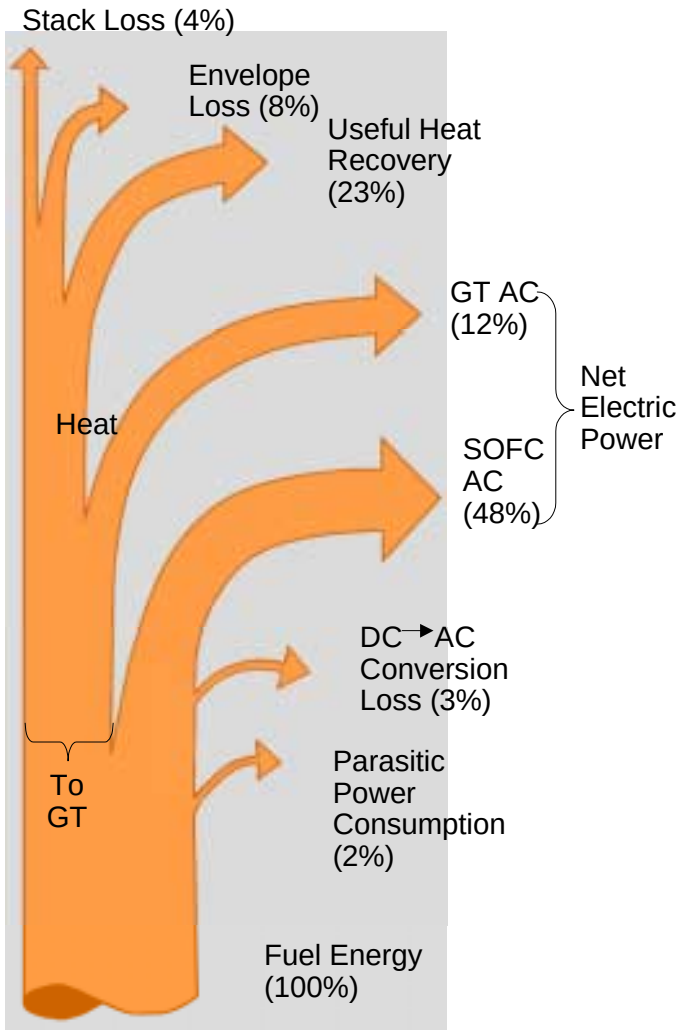
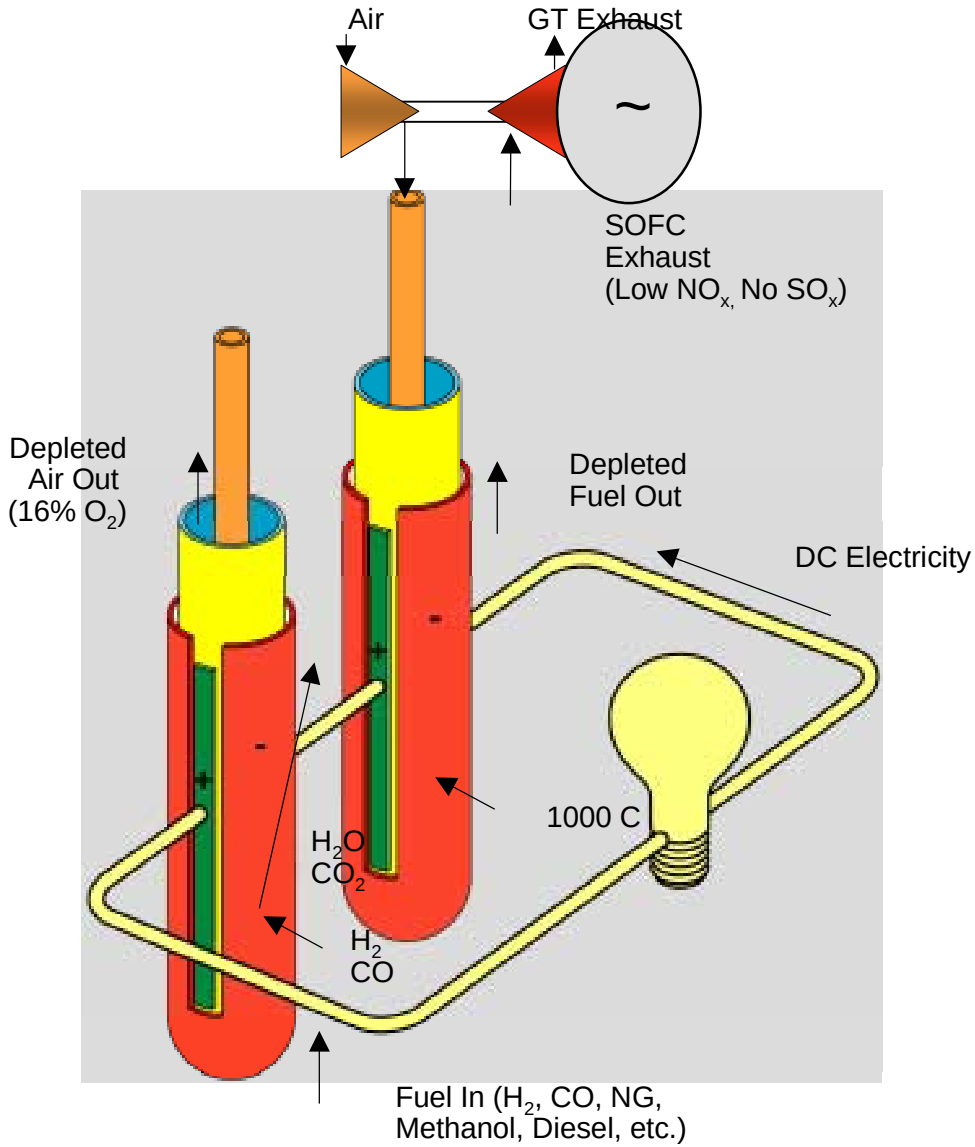
SOFC Demonstration Status

PSOFC/GT Energy Utilization





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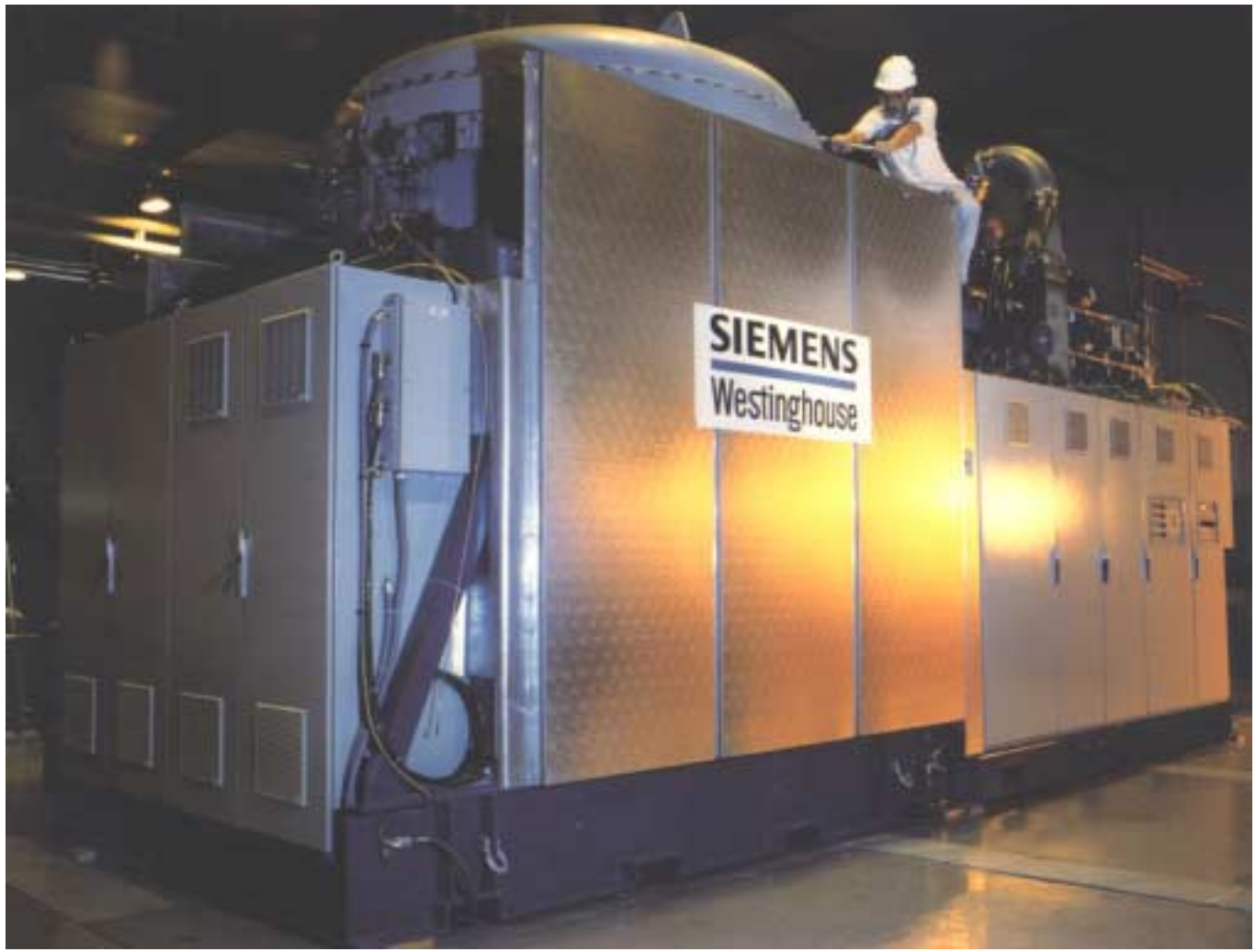
SOFC Demonstration Status

SCE 220 kWe PSOFC/MTG Installation



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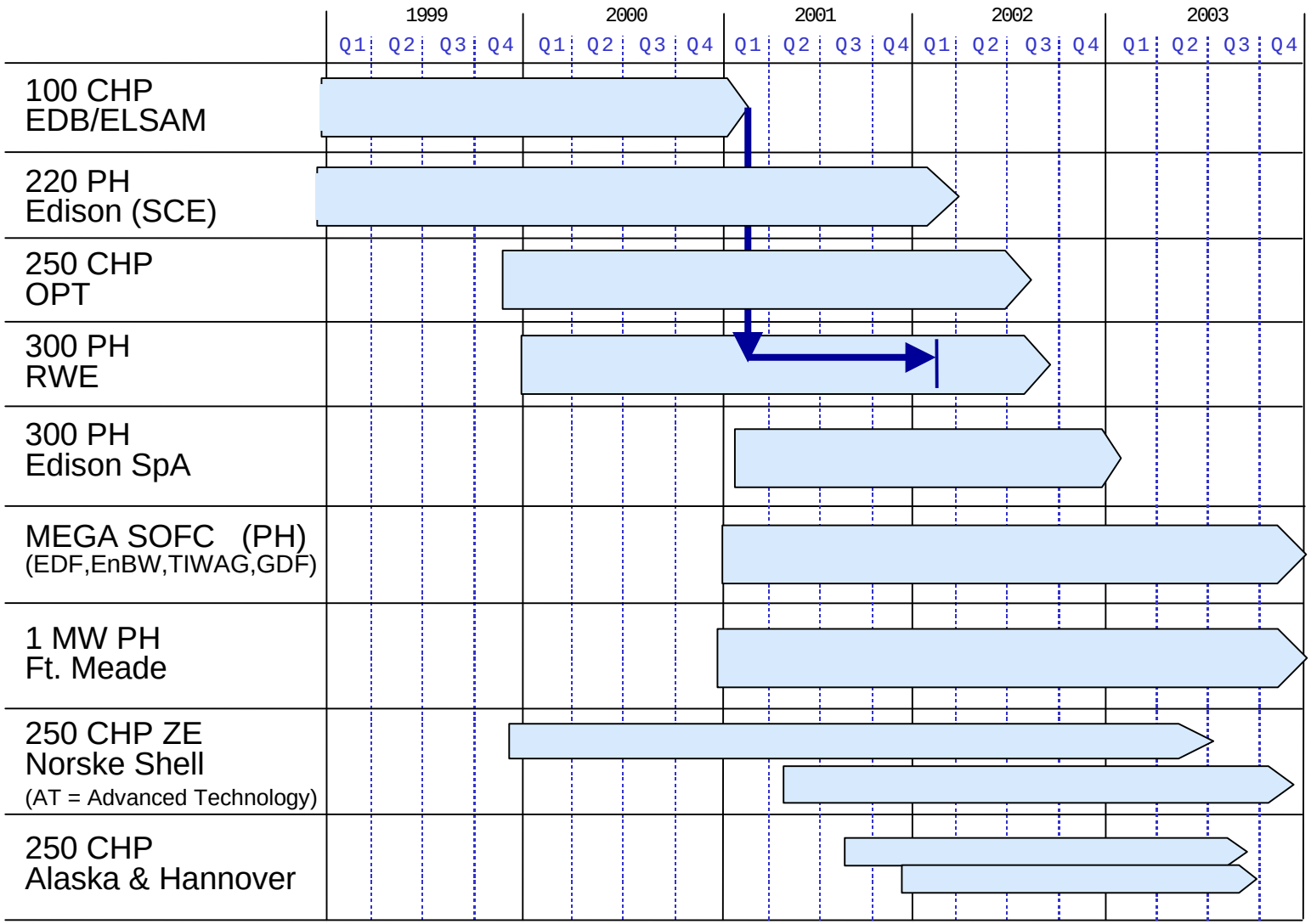
SOFC Status

Demonstration Projects



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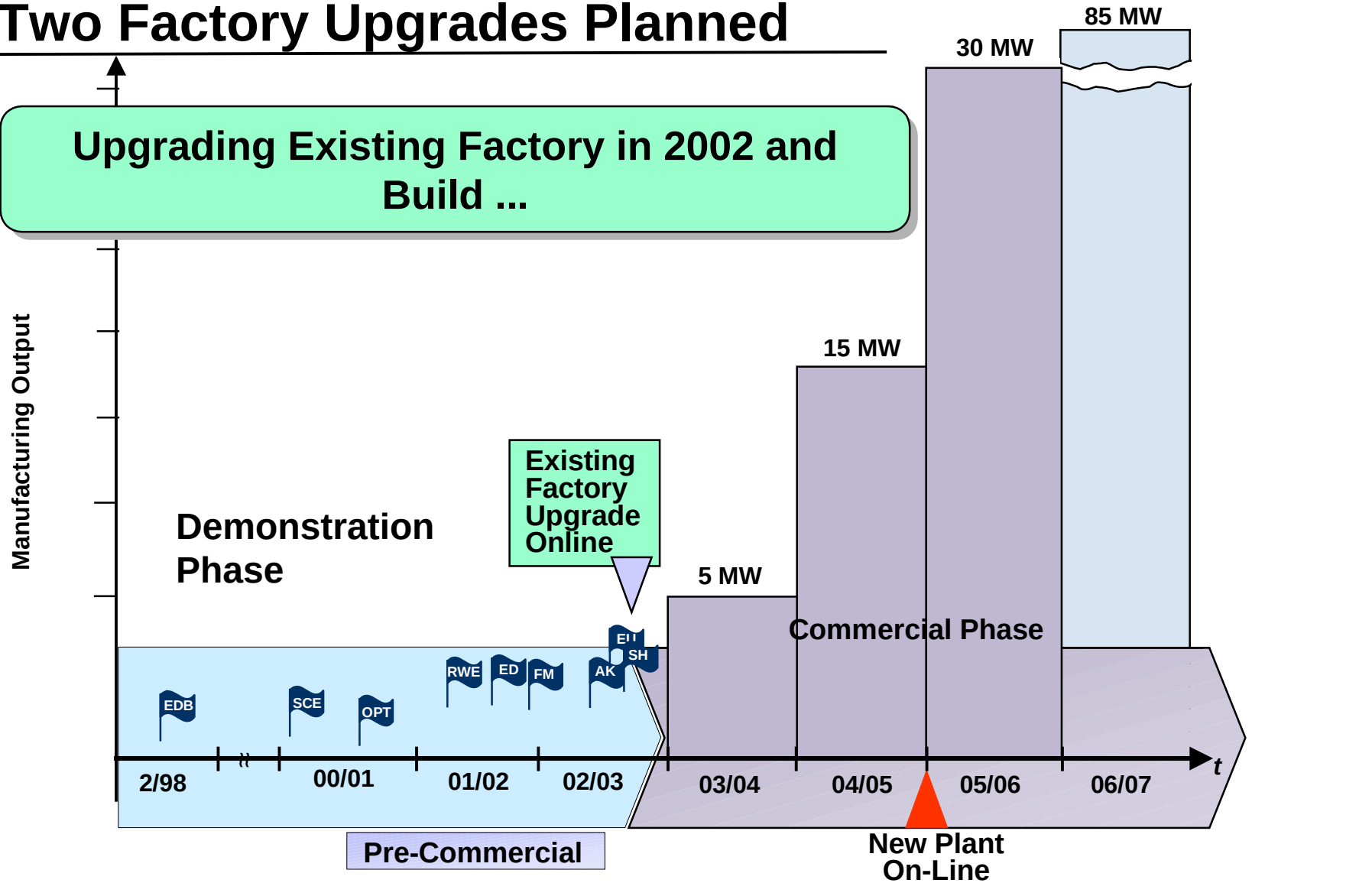
SOFC Commercialization Status

Two Factory Upgrades Planned



... New Factory in 2005 For Full Commercial Production

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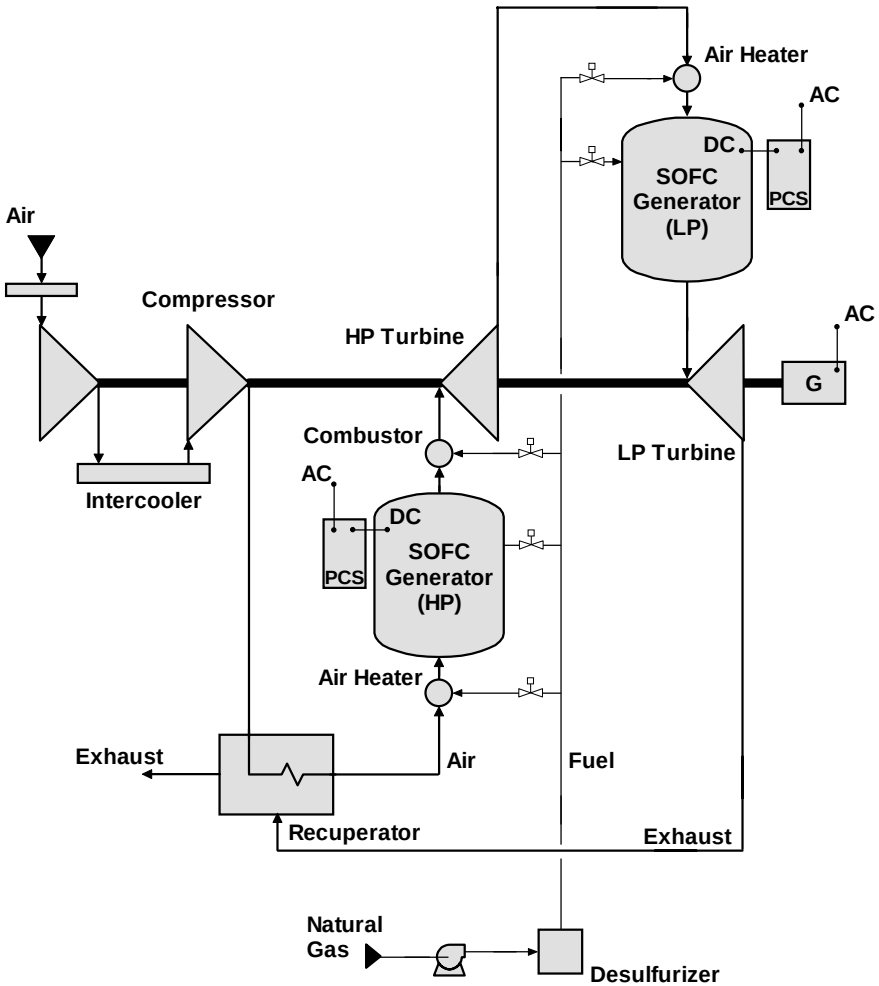
SOFC Future Potential

PSOFC/IRsofcR-GT Cycle ⇒ Higher Efficiency



- Peak Cycle Temperature 870C
- Optimum Pressure Ratio ~ 7:1

System Efficiency Horizon ~70% (Net AC/LHV)

Why Higher Efficiency Is Achieved

- HP SOFC Generator Operates at Higher Pressure ⇒ Higher Cell Voltage.
- Intercooled Compressor ⇒ Higher Brayton Cycle Efficiency.
- Gas Turbine Reheat ⇒ Higher Brayton Cycle Efficiency.

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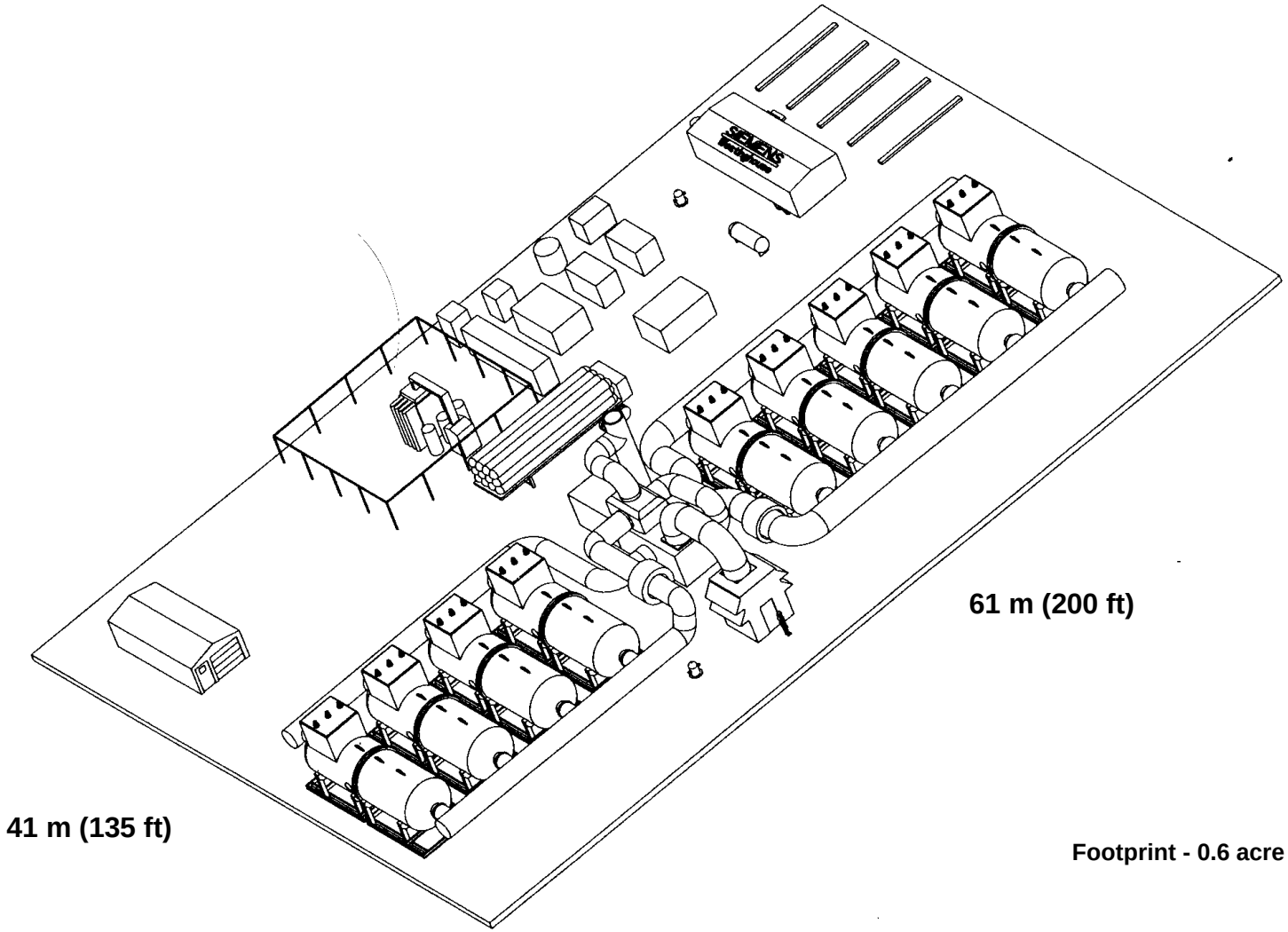
SOFC Future Potential

PSOFC/IRsofcR-GT @ 19 MWe



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SOFC Future Potential

PSOFC/IRsofcR-GT 19 MWe Performance

Compressor Air Intake Rate	18.1 kg/s
Compressor Pressure Ratio	9.0 MWe
LP SOFC Generator DC Power	7.5 MWe
SOFC Gross AC Power	15.6 MWe
Gas Turbine Gross AC Power	4.1 MWe
Power System Net AC Power	19.0 MWe
Fuel Flow Rate to Power System	0.62 kg/s
Efficiency (net AC/LHV)	67.3%
Carbon Dioxide Emission	300 kg/MWh
Nitrogen Oxide Emission (Based on 1.0 ppm_v)	0.006 kg/MWh

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SOFC Development
Summary

a) SOFC systems can operate on NG, liquid fuels, syn gas. High operating temperature enables SOFC/GT hybrid.

b) Commercial 250 kWe CHP systems operate at 45-50% elec eff (75% total). 4 demos planned.

c) 100 kWe demo already operated for >16,600 hours.

d) First hybrid PSOFC/GT system demonstrated. 5 demos planned

e) 300-1000 kWe PSOFC/GT systems offer 55-60% elec eff and 75+% total.

f) Multi-MW PSOFC/GT systems will operate at 60-70% elec eff.

g) A suitable MTG for PSOFC/GT ≥1 MWe awaits development.